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The agroecological transition of agricultural systems in the Global South

F.-X. Côte, E. Poirier-Magona,
S. Perret, P. Roudier,
B. Rapidel, M.-C. Thirion,
éditors

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Chapter 10

The drivers of agroecology in sub-Saharan Africa: an illustration from the Malagasy Highlands

Jean-Michel Sourisseau, Jean-François Bélières, Jacques Marzin, Paulo Salgado, Florent Maraux

The controversies that surround the various definitions of agroecology reflect the current debates on the future of agriculture, its place in societies and the evolution of agricultural models. Some definitions of agroecology are more strict in their injunctions against the use of synthetic inputs, others less so. Some concern themselves only with the productive dimension while others take agroecological practices across the entire food system into account. Some incorporate the social and societal dimension of agro-industrial systems and alternative food systems while others do not (Altieri *et al.*, 2017; Reboud and Hainzelin, 2017; FAO, 2015). Some advocate family and peasant farming, as defined by FAO[1], or small-scale agriculture (these different forms of organization are described in Bélières *et al.*, 2014). The different definitions of agroecology also refer to various forms of collective or public action: the production of public goods; the building up of local capacities to manage the commons (Perret and Stevens, 2006; Knox and Meinzen-Dick, 1999); the different forms of learning, from the most academic to peasant-to-peasant training (Altieri *et al.*, 2012). Furthermore, with the reorientation of public funding and/or the expansion of the control of market forces to new domains, the issue of the globalization of trade is now at the heart of the differences between the definitions of agroecology: some embrace the globalization of trade in a liberalized world whereas others stand firm in radical opposition to this globalization.

We do not intend to rule on these controversies in this chapter since very many authors have already done so (Wezel *et al.*, 2009; Altieri *et al.*, 2017; FAO, 2015) as do some other chapters in this book. This chapter aims at examining the dynamics of change driven by agroecological transitions in sub-Saharan Africa by incorporating, in line with the definitions proposed by FAO[2], all the economic, social and environmental

1. http://www.fao.org/resources/infographics/infographics-details/en/c/270462/ (retrieved 23 December 2018).
2. http://www.fao.org/agroecology/knowledge/10-elements/en/ (retrieved 23 December 2018).

dimensions of change. To this end, this chapter revisits the notions of agroecological transition and agricultural intensification, the latter's various forms being at the heart of reflections on the definitions of agroecology and challenges of development, especially in sub-Saharan Africa. We then explore the issues and possible drivers of the agroecological transition as well as the demographic and macro-economic context in this region of the world. Finally, on the basis of the example of family farming in the Malagasy Highlands, we show the weighty influence of structural and social constraints in agricultural dynamics and – despite the extent of these constraints and the temptations provided mainly by buoyant markets to modernize and implement Green Revolution models – the resilience of a form of agriculture with very little intensification, many of whose practices are agroecological, and which persists in the absence of structural transformation. We conclude on the inadequacy of solely technical solutions (even when their performance is accepted), at least in sub-Saharan Africa, to meet the challenges of increasing incomes while controlling disparities, improving livelihoods, increasing production when necessary, and managing territories in a context of sustained population growth. There is therefore a real need for renewal of agricultural, food and territorial policies to accompany and support changes in family farmer practices, and to stimulate development of territories that promotes and leverages agroecological practices.

A CONTROVERSIAL GLOBAL MOVEMENT WITH MANY LOCAL FORMS

In order to avoid ambiguity and to clearly describe the frameworks we use as reference in this chapter, it is necessary to list the main agricultural models found in sub-Saharan Africa.

Most of these models pertain to agriculture that uses few inputs (fertilizers or pesticides), has low levels of mechanization, and incorporates practices with agroecological aspects (use of peasant seeds, crop associations and rotations, short fallows, crop-livestock associations). For the sake of simplicity, we will call these models 'traditional' even though we admit that they originate from a historical process of adaptation. These combine on- and off-farm activities, with agriculture often being just one component within complex activity systems. Indeed, agricultural households strive above all to optimize the performance of these activity systems, and thus to optimize the contribution of agriculture within these systems.

Alongside these traditional models, there exists another set of agricultural models – whose implementation in this region of the world is not easy and thus its instances are encountered in very small numbers – that specialize in agricultural exports or in supplying to cities, with a higher level of intensification through the use of improved seeds and synthetic inputs, animal traction, often with greater control over water use. We will call this form of agriculture 'conventional', in reference to the Green Revolution model of intensification, now found across the planet.

Finally, a third set of agricultural models exists in specific situations. It includes agricultural production with foreign investments, especially on irrigated perimeters; alternative forms of agribusiness funded by national investors, generally novices

themselves in agriculture; and highly capitalized farming in South Africa and in a few dedicated zones elsewhere. We will call this set of models 'mechanized conventional' since increased mechanization accompanies the intensification through inputs, significantly increasing labour productivity by reducing the amount of labour required for agricultural production.

At the global level, conventional agricultural models, whether mechanized or not, are being condemned for their negative environmental and social impacts and their lack of sustainability. Indeed, the research community has arrived at a consensus regarding their undesirability and shortcomings (IAASTD, 2009), as have international bodies governing agriculture and food (FAO, 2015, 2016). But the development of these conventional agricultural models is still being pursued implicitly in national and regional agricultural policies in sub-Saharan Africa. In this region, the necessity of intensifying production to increase food, energy and fibre biomass and to satisfy a growing demand takes precedence (this necessity, although less shared today on a global scale than in the past, remains generally accepted). In the end, the proposed solutions to the requirement of an agriculture that is more productive and, at the same time, less harmful to the environment and society, differ so much so that they become polemical. They range from the advocacy of the principles of the Green Revolution (Agra, 2016), to its softening through more natural resource-friendly ways (Griffon, 2013), to a call for radical paradigm shifts based on the ecologisation of production and the complete overhaul of food systems (Altiéri, 2012; Giraldo, 2018), or, on the contrary, to the exploration of agricultural models turned firmly towards new technologies and extreme artificialisation (Thérond *et al.*, 2017). But irrespective of the options selected, the solutions to the challenges facing agriculture all call for changes to the entire agrifood system; we cannot focus solely on the sector of production.

The debates around agroecology thus refer to divergent conceptions, largely pertaining to the circumstances of their emergence:
– an agroecology of practices, based on technical and organizational changes that do not affect the overall governance of agrifood systems and which is driven by the knowledge and understanding of the negative environmental externalities of the Green Revolution's technical model;
– an integral agroecology, more political, advocating a change of technical paradigm as well as a recomposition of food systems, breaking with the industrialization of production and consumption models (Giraldo and Rosset, 2018).

It seems necessary to add a third conception, corresponding to 'traditional' agriculture, especially prevalent in sub-Saharan Africa. It is not a matter of ecologising intensive agricultural practices but instead of intensifying practices that are already predominantly agroecological. Indeed, in this region, production systems have either incorporated the practices of the Green Revolution very minimally or have ignored them altogether. But they have to intensify production to respond to the demographic pressure that is fragmenting family farms and to growing consumer demand from both urban and rural areas. The pressure on resources increases the vulnerability of these production systems, whose sustainability depends on farmer knowledge and know-how that is little needed in the other two conceptions of agroecological

transitions defined above. This local knowledge offers solutions adapted to soil fertility, crop associations and rotations, the diversification of production, the maintenance of cultivated biodiversity, crop protection, crop-livestock integration, the integration of trees into agricultural production processes, etc.

Table 10.1. Main characteristics of the three conceptions of agroecology.

	Agroecology of practices	**Integral agroecology**	**Agroecological intensification**
Type of farm	All	Small family farm	Family farm
Market integration	Maximum	Limited	Variable
Food system	Globalized	Territorialized	Variable
Labelling	No	Possible	No
Scope of change of practices	Plot and herd	From the plot and herd to the landscape	Plot, herd, and farm
Types of inputs	Synthetic	Variable, but in rather small quantities	Variable
Diversification of production	Not sought	Yes	Yes
Type of incentives	Case by case	Mixed	Few until now
Use of GMOs	Yes	No	Usually no

While these debates on the conception of agroecology are global, they also have a local dimension. The possible options vary widely depending on market dynamics and economic and social performance at a national or regional level. They also differ depending on whether the governance of agriculture and the food sector is conducive to implement and support changes effectively, and on how advanced are the Green Revolution processes of artificialisation and specialization (Baret *et al.*, 2013). An agroecological transition is invoked by all stakeholders advocating a change in practices and a break with conventional agriculture, mechanized or unmechanized. When this notion of 'transition' is applied to agriculture in sub-Saharan Africa, it refers to more than the simple injunction to 'go from one state to another'. It encompasses the leveraging of ecological practices and an evolution in the functions that agriculture must fulfil for society. But used in this way, it seems to describe a linear and comprehensive movement, even though the paths of ecologisation are extremely diverse. In particular in many developing countries that have at best only partly implemented structural changes in their economies, it has to confront specific challenges of creating jobs in unprecedented numbers, required due to rapid population growth and because industry and manufacturing still create very few of them (Pretty *et al.*, 2011; Losch *et al.*, 2012).

The 'agroecology of practices' and 'integral agroecology' conceptions refer most frequently to the conversion of post-Green Revolution agricultural models with high labour productivity and intensive use of synthetic inputs, water and land to more environmentally friendly models that leverage natural ecological processes in their technical itineraries and minimize their negative impacts on the nutrition, health and social equilibrium of the populations concerned (Gliessmann, 2015; IAASTD, 2009; IPES-Food, 2016; Griffon, 2017; Duru *et al.*, 2014). But entire sections of

African agriculture have never become part of the Green Revolution's productivist system. They do use agroecological practices but need to increase their productivity and therefore to intensify these ecological processes. In these situations, agroecological intensification is called for more than agroecological transitions. Indeed, in sub-Saharan Africa, the starting point of trajectories of ecologisation is a predominantly 'traditional' family model of farming because it is based on knowledge and know-how often ignored by the proponents of globalized research; the starting point is not an intensive productivist model which would moreover also lead to technological dependence. The drivers of change and the levers of agricultural policies are therefore radically different from those aiming at an agroecological conversion as advocated in Europe or in North America.

In sub-Saharan Africa, research is being conducted on the possible trajectories of agroecology, in particular by the IPES-Food[3] expert panel, the Alliance for Food Sovereignty in Africa (Afsa, 2016), and the ProIntensAfrica and LeapAgri[4] European programmes. Scientific repositories on the various forms of sustainable intensification (at least described as such in the literature) also exist, whether with a global scope such as conservation agriculture or agroforestry, or whether concerning only specific technical elements, such as integrated pest and disease management (Scopel *et al.*, 2013; Pretty *et al.*, 2011; Tittonell *et al.*, 2012). Thus, the ecologisation of agriculture can draw on the results of a growing amount of research and innovation. Proposals, often backed by research studies, focus on technical options for shifting 'traditional' agriculture towards alternative models and principles. These innovations usually combine a small amount of the knowledge specific to local territories and ecosystems with exogenous elements that have been proven elsewhere, most notably during agroecological transitions of conventional agriculture (mechanized or unmechanized) undertaken in industrialized or emerging countries. This hybridization between local knowledge and exogenous knowledge is a veritable scientific challenge because it must, on the one hand, create *ad hoc* statistical tools to take into account the complexity of traditional practices and, on the other, construct new knowledge specific to agroecological intensification of traditional practices in sub-Saharan Africa.

Furthermore, agroecological transitions are often promoted without any specific prior reflection on the conditions required for and the available room for manoeuvre in a true transformation of agricultural and food systems. And yet, any technical change (use of new inputs and materials) or organizational change (emergence of value chains adapted to different forms of agroecology and integration of producers in these value chains, emergence of logistical and organizational chains for supplying planting material or organic manure and for supporting small-scale mechanization) requires physical and cognitive capacities that are not immediately obvious. The emergence of agroecological intensification in sub-Saharan Africa must enable farms to move beyond the defensive logic of adapting to risks and pressures on resources which curbs their ability to innovate (Whiteside, 1998). Technical innovations must be accompanied by favourable changes in the environment not only of family farms but

3. http://www.ipes-food.org/_img/upload/files/West%20Africa%20concept%20note_EN.pdf (retrieved 7 May 2019).
4. www.intensafrica.org, http://www.leap-agri.com/

also of all actors involved in food systems: improving access to means of production and market-friendly public goods (communications, transport, storage, regulations, traceability, etc.), and the structuring of the actors in the various agri-chain and food system segments so that they can influence the definition and implementation of agricultural development strategies and even of the models of development.

Finally, the polysemy, the inaccuracies and incompleteness of the concept of the 'agroecological transition' call, especially in sub-Saharan Africa, for an improved understanding of the aspirations of the different types of actors and of the actual drivers of agricultural transformations at different levels of decision-making and coordination. This understanding applies to production systems and agrifood systems. It also applies to the capacity of States to orient food and agriculture evolutions and to build up the capacities of stakeholders. Before we take a look at the case of the Malagasy Highlands, we will find it useful to discuss the sometimes ambiguous relationships mentioned in the literature between agroecological intensification and agroecological transition.

Old debates partially revived

Agricultural intensification is mainly defined along three main dimensions: higher yields per hectare for a given crop; higher yields per unit of time due to an increased number of crop cycles per year; replacement of low-yield varieties with those that have higher yields per hectare or generate higher incomes per unit of production (Naylor, 1996).

The equating of intensification to an increase in the quantities produced (of goods and/or their value) and to the growth of factor productivity (land, capital, labour) refers to an older and wider debate on the causes and drivers of agricultural transformation. According to Le Bras (2003), despite their divergences, Malthus and Boserup, in their approaches to the links between livelihood production and population growth, both define intensification as the quest for the best combinations of resources and production factors to meet subsistence needs. The requirements of mathematical modelling have led, in the attempts to formalize the work and conclusions of these two seminal authors (from the works of Quetelet to those of Solow), to the simplification of their hypotheses. In this simplification, intensification is no longer a matter of equilibrium but instead a quest for increasing the overall productivity of factors, especially labour and land, in order to generate a higher monetary income at the farm level. The same simplification is at work in the agronomic conception of intensification. Rather than seeking an equilibrium, the quest for a permanent increase in the quantities produced and in incomes leads to the introduction of an imbalance, which then has to be managed over time. This exigency of managing the imbalance forces farmers to shift from a quest for subsistence self-sufficiency to an increased reliance on stakeholders and elements outside their farms and food systems.

In line with the Malthusian and Boserupian principles of agricultural intensification as redefined by Le Bras (2003), we can recast agroecology as the search for a balance in the management of a set of resources. In these authors' framework, this balance is first and foremost a response to increased pressure on natural resources,

especially due to demographic growth and the associated need for increased production (Bonny, 2011; Brookfield, 2001). But this reasoning can be extended to monetary needs, climate change adaptation, biodiversity conservation and restoration and, more broadly, the production of public goods benefiting society as a whole. In this more holistic reasoning, the drivers of intensification and agroecological transitions will no longer be solely focused on increasing production in volume and value (Duru *et al.*, 2014).

Therefore, agroecological transitions should be intensification movements aimed at maximizing, for society as a whole, a set of environmental, social and economic services that ensure the sustainability of agricultural production, food systems and the development model. While 'integral agroecology' is in line with this definition, the 'agroecology of practices' – with its more limited scope – is not. It is essential to conceive agroecological intensification in the light of these objectives.

It is important, especially in the context of agroecological intensification for sub-Saharan Africa, to accord value to environmental and social services, either through the prices of goods and services along the agrifood chains or through other non-market incentives. The necessary changes are significant and difficult to imagine without strong public action not only to ease the constraints on actors who want to initiate transitions, but also to promote price relationships that do not penalize these actors in the face of competition from those who do not engage in ecologisation. It is clear that the different agricultural models are not equal in terms of the levers they can mobilize and the support they can expect from public authorities.

The agroecological transition in the context of the major challenges confronting sub-Saharan Africa

Sub-Saharan Africa is the last major world region to begin its demographic transition.[5] The rate of decline is much slower than those experienced earlier in other parts of the world, especially Asia. The current population in sub-Saharan Africa is expected to double to 2.5 billion in 2050, while China and Europe will see their populations decrease during the same period (Losch, 2016b). Africa will account for 53% of the increase in the world population in the next three decades (United Nations, 2017). This is due to the high number of children born per woman on the continent – between four and five for Africa as a whole and up to more than six in some countries in the Sahel.

One of the consequences will be the densification of most rural areas. Sub-Saharan Africa is urbanizing rapidly (between 2014 and 2050, the share of the urban population in the total population will increase from 37% to 55%), but the rural population will continue to increase after 2050. Furthermore, this region will probably not be able to fully benefit from the demographic dividend, the favourable period in a country's history when the economy takes off, during which the ratio of inactive to active workers declines, with fewer dependent youth not yet of working age and as yet few older people

5. This section draws largely on *Une nouvelle ruralité émergente, Regards croisés sur les transformations rurales africaines*, published by NEPAD and CIRAD (Pesche *et al.*, 2016).

(as has happened in other parts of the world). This phenomenon will be weak and dissipated in this region because of the slow decline in fertility while the aging of the population accelerates because of longer life expectancies (Guengant, 2011).

A mass of new workers will struggle to find employment in the poorly diversified national economies where primary and especially agricultural activities still provide the majority of employment. Indeed, another specificity is that the sub-continent is not yet engaged in its economic transformation. Young people entering the labour market are unlikely to be employed by a still embryonic manufacturing sector or a small formal tertiary sector. They will have to find jobs or activities in agriculture or in the informal urban sector, which while dynamic currently offers few decent jobs. Furthermore, while the informal sector can be a source of innovation and creativity, it offers few levers of redistribution because it escapes taxation. More broadly, the dynamism of this informal sector raises the question of a need to renew modes of governance to better recognize it, so that the economy can be modernized and diversified outside the primary sector.

This overview compels us to question the capacities of the agricultural sector to meet these challenges. The rapid modernization of agriculture in 'developed' countries has led to a concentration of the means of production in a smaller number of farms and to a rapid increase in labour productivity thanks to mechanization and, consequently, to a shift of a large part of the agricultural labour force to other sectors. In sub-Saharan Africa, any such process of modernization will be constrained by the insufficient diversification of national and territorial economies.[6] Unable to rely in the medium term on industrial development or on the formalization of the tertiary sector, agricultural models and the various types of intensification will have to offer decent jobs to the majority of the working population which is still in fact, by choice or lack of choice, in agriculture. It is therefore necessary to adopt strategies of economic diversification while maximizing the employment potential of agriculture (as also, more broadly, of the entire primary sector), which requires us to go beyond sectoral reasoning alone (Losch, 2016a).

Sub-Saharan Africa therefore still needs agriculture to be the engine of growth and transformation. But this agriculture needs to be inclusive, anchored in ever-densifying territories, provide increased income and food security for rural and urban dwellers, and generate decent jobs in massive numbers in rural areas. It must do so in a context of high vulnerability of the agricultural world and of climate change that is fast modifying the conditions of production. And it must also do so in a globalized, increasingly competitive market, with volatile national and international prices of agricultural products, and the pressure of prices of conventional inputs (whose production is concentrated in industrialized countries), even as African countries have ever fewer possibilities of protecting their agriculture from outside pressures.

Agroecological intensification as defined above seems to be a promising path for sub-Saharan Africa, especially to confront the challenge of employment (Pretty *et al.*, 2011). The (albeit rare) comparisons in the literature between agroecology

6. Since the urban architecture of sub-Saharan Africa is characterized by the domination of capital cities and secondary towns with weak infrastructure and little economic diversification, the issue of agricultural employment becomes even more strategically important in most territories.

and conventional forms of agriculture in terms of employment and performance confirm this potential (Pimentel *et al.*, 2005; Altieri *et al.*, 2012). In addition, agroecological practices seem to be well-adapted to the social, economic and ecological environment of the sub-continent's family farms: they are less intensive in physical and financial capital, and they better leverage *a priori* the social and cultural capital of rural territories and local resources (knowledge, natural resources, etc.) without leading to technological dependencies. Such agroecological intensification would require, as would the generation of decent jobs, the services rendered by a more virtuous agriculture, currently mainly non-commercial, to be remunerated. It would also require far-reaching voluntarist policies to be put in place. Such viewpoints, however, are not in line with the changes in agriculture and food systems currently being promoted in sub-Saharan Africa. Policies oriented towards the quest for competitiveness in globalized commodity markets, modelled on those of the Green Revolution, still dominate.

At the level of the sub-continent, demographic pressure and uncertainty over the availability of productive resources, especially land, drive agricultural transformations and not market signals, the preservation of the environment or the ability to change food systems.[7] Land pressure generated by foreign or domestic corporate investment in agricultural production is another factor contributing to the weakening of traditional agriculture. It should also be noted that national and local public policies have, in the recent times, had little positive impact on transformations of agriculture and the food sector. The most striking innovations are those conceived by producers and food system actors themselves, and they are more in line with a strategy for preserving the means of production and diversifying income-generating activities than an ecologisation of practices. The example of the Malagasy Highlands, which we describe in the next section, is an apt illustration of these constrained mechanisms.

A restricted development of agroecology: the case of the Vakinankaratra region in Madagascar

Our case study takes a look at factors that block transitions in production systems, and opens up perspectives for a better taking of food systems into account to remove these blocks. In the Vakinankaratra region in Madagascar, the favourable natural environment for agriculture production, the diversity of production systems, the farmers' know-how and some more or less well-structured agri-chains involving different public and private actors all constitute a real potential for agricultural development. But agricultural policies have not so far been able to trigger the structural transformation of agriculture and the rural economy, either through conventional intensification – even though widely promoted – or by encouraging the intensification of existing agricultural practices. These polices will thus be forced to evolve given the already high and steadily increasing demographic pressure.

7. For examples, see the case studies describing the drivers and realities of agricultural intensification in sub-Saharan Africa at http://www.intensafrica.org.

The obstacles in the path of agricultural intensification

Over the last 20 years, three major and broadly contrasting orientations have characterized these policies, largely inspired by the major international agencies:
– the withdrawal of the State;
– the desire to increase production not only to ensure the food security of a growing population, especially urban, but also for exports;
– the taking into account of environmental aspects, in particular at the instigation of the major international conservation NGOs, as also with the integration, at least partially, of the concept of sustainable development in the drafting of rural policies (Raharison, 2014; Bosc *et al.*, 2010).

Agricultural policies were essentially aimed at promoting conventional intensification and saw an acceleration during the 2000s. Most importantly, given the limited public funding resources, it became necessary to introduce tax incentives for agribusinesses to establish themselves in the country and set up economically efficient production agri-chains (Burnod *et al.*, 2011). At the same time, aid was provided to facilitate access to inputs for small-scale family farming. These policies have not produced the expected results because of institutional bottlenecks and the inadequate production and market infrastructure. Irrespective of the size and form of the production units concerned (poorly differentiated and poorly equipped family farms, or foreign-funded agribusiness companies), the production and market environments remain extremely unfavourable. More recently and gradually, policies have begun advocating agroecological intensification practices, notably with the promotion of the system of rice intensification (SRI; Serpantié, 2013) and conservation agriculture (Penot *et al.*, 2015), but these practices have not seen any significant adoption so far. For example, in mid-western Vakinankaratra, only 2% of farms use planting under cover techniques, four years after a dissemination project ended (Razafimahatratra *et al.*, 2017). There has been limited and insufficient conventional and agroecological intensification, with farmers having to deal alone with changes in an environment that is not conducive to risk-taking. Agricultural policies are not solely responsible, however. At the national level, the succession of political crises since independence has led to the deterioration of the main socio-economic indicators (see in particular Razafindrakoto *et al.*, 2017) and to a blocking of structural change.

The country remains very agricultural: almost 80% of households have at least one member participating in agricultural activity (Instat, 2011). There is widespread rural poverty because of the low agricultural productivity as well as – and especially so – because the factors of production are not available to families. Even though the population has doubled in a single generation, the secondary and tertiary sectors are struggling to develop and are unable to absorb the young people entering the workforce; the agricultural sector thus absorbs most of the population growth. At the macro-economic level, the net per capita production index is declining as is the ratio of exports to imports of agricultural products. Due to increasing population pressure, productive resources are being exhausted and in most cases no longer allow families to meet their needs.

According to agricultural censuses, in 1985, the average surface area per farm in Vakinankaratra was 1.07 ha. This figure had dipped to 0.55 ha in 2005 (MAEP,

2007) due to population growth and the intergenerational transfer and division of family assets. The proportion of farms that were smaller than 1.5 ha in area was 84% in 2010 (Instat, 2011). The average number of cattle per farm declined from 6 to 4 in 20 years. These continuing trends are resulting in very high land pressure in some areas today, with average holdings of 0.4 ha and only 3.3 heads of cattle (Sourisseau *et al.*, 2016). And yet, there are very sparsely populated areas across the country and even in the Vakinankaratra region, which are potential spaces for the extension of agriculture. But these areas are remote, without infrastructure and suffer from a lack of security. There exist no significant land development policies that could allow the shifting out of small family farms from the most densely populated areas (Bélières *et al.*, 2016). Farms instead rely on intensification strategies that involve the diversification of activities.

The figures cited in the following paragraphs are taken from two studies. The first is on the functioning of farms and the agrarian system in mid-western Vakinankaratra (Razafimahatratra *et al.*, 2017). The second focuses on the trajectories followed by 24 family farms in the region, endeavours to understand the implementation over time of intensification processes (Rakotoarisoa *et al.*, 2016), and then identifies perspectives for enhanced ecologisation of agriculture (in the sense of an improved integration of natural processes in cultivated processes) that could be propitious to development.

Farms with the highest farm incomes in absolute terms and by family worker are those that undertake the most activities: lowland rice, rainfed crops on hill slopes (*tanety*), fruit or market-garden production, dairy farming, small-scale livestock husbandry, combination of on- and off-farm activities, etc. Rice farming, especially in its irrigated or flooded form, occupies a prominent place in the farms' portfolios (42% of the cultivated surface area and 58% of the gross crop production) because it ensures the family's food base and, in addition, because enough production is left over for sales (about one-third of the production). Many other crops are grown: 40 annual or perennial species were encountered in a survey of 240 farms (Raharison *et al.*, 2017). Close to half of the farms include at least four major crops in their rotations: rice, maize, legumes, and tubers. The practice of crop association is widespread: 78% of farms have at least one plot cultivated in association, and a total of 22% of the plots by number and 27% by cultivated area are covered by crop associations, a significant quantity given that lowland rice accounts for 28% of the annual surface area and is cultivated as a pure crop. The associations are very diverse: a total of 44 different ones were encountered. In general, polyculture is combined with livestock farming. Cattle, swine and poultry farming are practised by 70%, 65% and 80% of households respectively. Cattle husbandry is widespread with 56% of the holdings owning at least one zebu, but the distribution of the animals is uneven (4% of holdings own 36% of the capital represented by the animals). Livestock husbandry provides animal traction and most of the manure applied to the fields. The use of purchased agricultural inputs and, in particular, of mineral fertilizers, remains low: 24% of farms use them at a dose of less than 40 kg/ha/year, which works out to an average dose of less than 20 kg/ha/year across the region's total cultivated area (Razafimahatratra *et al.*, 2017). Phytosanitary products are used a little more (40% of farms), but at very low doses because they are mainly limited to insecticides and fungicides to treat seeds (average annual

expenditure of 10,000 Ar[8] per farm, i.e. less than 3 €). The use of veterinary products is more widespread (79%) but the average amounts are again small (41,000 Ar/year, or about 10 €). Labour costs (daily labour or paid by the task) account for 90% of the total cultivation expenses. Labour remains mainly manual, although animal traction is widespread (43% of farms). The majority of farms choose to use organic manure originating from livestock effluents. Due to small acreages, farmers prefer to recycle nutrients within the farm to save cost. The saturation of lowlands for irrigated rice cultivation has favoured the cultivation of rainfed crops, especially rice, on hill slopes. The extension of rainfed rice is therefore a form of agroecological intensification through diversification and improvement of the rice systems themselves, for which the research community has provided substantial support.

Diversification of activities is a part of anti-risk strategies for dealing with shocks. Thus, following the political crisis of 2009 – which brought the activities of one of the largest milk processing companies to a halt, led to a sudden deterioration in market conditions, and resulted in the loss of outlets –, some dairy farmers who were engaged in a process of conventional intensification turned instead towards agroecological intensification processes in an effort to reduce their dependence on the supply of inputs. Diversification is a structural element of the intensification strategy itself, which aims at a better leveraging of the farm's resources by relying on the integration of activities and on their complementarities. The most intensive and most productive farms are generally those that are the most diversified. These characteristics, combined with low use of mineral inputs and a virtual absence of motorization, move these farms away from the principles of conventional intensification. Their practices pertain instead more to an agroecology that optimizes resources and local knowledge. The systems are diversified, based on crop associations and rotations, crop-livestock integration, landscaping with mainly manual labour (rice fields and terraces), intensification through labour (manual transplanting, thinning, weeding), etc. There is even some resistance to the adoption of conventional techniques, most often due to difficulties of access or cost considerations, but also sometimes because of cultural references concerning 'respect for the land'. Much more is at work here than just anti-risk strategies, with practices that rely on real know-how and empirical knowledge of agroecology, which could even provide inspiration to the research and development communities (Raharison *et al.*, 2017).

Surveys show that the availability of factors of production and their suitability for economic and social needs are the key elements of evolutionary processes. Imbalances between farm demographics and the distribution of the means of production prevent changes and have adverse effects on farm productivity. The most frequently encountered imbalance pertains to land. A farm that sees its family workforce increase while the already limited land available to it remains the same no longer has the resources to increase family labour productivity on the farm. The family can supplement its income only by looking for off-farm, often low-paying, activities (agricultural labourer, coalman, brickmaker). And yet, productive capacities are sensitive to the fragility of the human capital: diseases and deaths are shocks that sometimes force farming fami-

8. Ariary, abbreviated Ar, is the Malagasy currency.

lies to sell traction cattle or land. The land market is indeed very active in this region of Madagascar, with transactions taking place mainly between family farms. While this phenomenon does not lead to real land concentrations, there are inequalities; the less well-fortunate families work as labourers on the richest farms. These factors restrict investment capacity and limit a family farm's room for manoeuvre in its effort to intensify its agricultural activities.

The trajectories are moreover fragile and sensitive to external shocks. In the sample surveyed, several farms suffered one or more shocks that often contributed to drops in the families' standards of living. The most common shocks result from climatic hazards, insecurity (theft) and pest damage. Some farms have seen their entire herd succumb to disease; others have seen their herds, painstakingly built up over the years, stolen in one night.

At the technical level, access to land, the reduction of arable land and access to agricultural inputs of all sorts remain major constraints. Seeds of improved varieties and agricultural inputs are difficult to obtain due to lack of distribution channels, high transport costs and a weak private sector. Moreover, at present, given the relative prices of inputs (high) and agricultural products (low), it does not make economic sense to use inputs, all the more so since the prices of agricultural products fluctuate sharply.

Price structures are unfavourable to producers, given the fragmented supply, non-existent infrastructures and agri-chains dominated by traders (collectors and wholesalers) who impose prices. The lack of organization of markets and their poor performance, in conjunction with a chronic weakness of producer organizations and the fluctuation of prices, are real roadblocks to improving farmer incomes. The low level of agricultural productivity is also linked to the very limited capacity of farmers to make productive agricultural investments. Only 10% of rural households take loans from financing institutions, and this at very high rates of interest (often around 3% per month). In the sample, farms in a favourable situation were those that have been able to invest recently in production factors (especially land). These investments were made possible by farm or off-farm income, or through risky actions, such as the sale of livestock, especially traction cattle, in order to take advantage of an opportunity to buy land.

Prospects for deriving benefits from agroecological practices

One of the main constraints of the region's family farms is their very low productive capacities (land, animals, material and equipment, land development). Policies that encourage these farms to derive value from existing land reserves will have to be adopted. This requires agricultural policies to be conceived as part of comprehensive territorial planning policies: roads, security, social infrastructure, and aid for setting up farms in new areas. Investments over the medium term in already cultivated areas are also needed: development of terraced or paddy fields; sources of funding to allow the amendment of land; the dissemination of varieties adapted to rotations, associations and double cropping; the development of agroforestry and conservation agriculture techniques; the purchase of animal traction equipment and motorized equipment;

the purchase of improved but sufficiently rustic animal breeds, etc. Combinations of comprehensive territorial planning and investment support for family farms, including for labour, can act as levers, provided that the farms of the most vulnerable receive significant subsidies (HLPE, 2013).

At the same time, innovations must be designed for diversified and highly agroecological systems. The dissemination of very targeted innovations for a cropping system or a livestock husbandry unit, with the application of conventional intensification techniques, leads to specialization and increases the farm's vulnerability. Such targeted innovations can only have limited impacts on the overall productivity of the family farm and, in particular, on income per family worker. The relevance of innovations has to be assessed in terms of the increase in this income per family worker and its long-term stability. Since this income results from complex activity systems, only systemic approaches can be used to understand and improve the processes underway on farms and in the territories to which they belong. A new production, variety, equipment or technique may well be successful in improving agricultural productivity, but to be sustainable, this improvement must be perceived throughout the entire activity system. Given the producers' low investment capacities, the innovations proposed will have to rely mainly on taking advantage of available natural resources and the intensification of natural processes within production systems. But the dynamics of agroecological intensification have to be more in line with the interrelations between the different parts of the systems implemented.

Similarly, it is important to have assured outlets for production and to integrate farms into more organized and better articulated agri-chains. And given the low level of each production, performance must be assessed in terms of the results of a combination of agri-chains and activities. So far, in Madagascar and elsewhere, agricultural intensification has been driven by a specialization of producers and agri-chains, with a gradual vertical concentration by companies seeking to control part of the growing markets of the globalized food system. Agroecological intensification is intrinsically diversified and products can be marketed only through a range of agri-chains and operators, also diversified, which is certainly not conducive to economies of scale and the optimization of technico-economic processes. Under these conditions, agroecological intensification does not lend itself, *a priori* and especially in the Malagasy context, to specialization and the vertical integration of agri-chains. It calls for a more 'flexible' organization of the agrifood system's upstream components – agri-supply, bank credit, and production services – to meet both the demands of the market and the diversity of productions. However, one should not assume that specialization and professionalization go hand in hand. On the contrary, agroecological intensification requires more professionalization on the part of producers and other actors, especially upstream of production.

In this respect, greater coordination between the local authorities and the central State, favouring a territorial and holistic vision of transformations, is desirable and would make it possible for the gains of an agroecological intensification to be perceived at the level of the farms' activity systems. It is also useful to strengthen farmer organizations to fight against asymmetries along the agri-chains, make development actions

sustainable over the long term and position them in a systemic perspective. The research and development communities should engage in improving their knowledge of food systems as a whole and of the place of producers and their organizations in these systems.

Policies change regularly, but often promote imported models – or, at best, hybrid ones –, with very little support for investment in family farms, a tendency towards sectoral and specialized visions, and a lack of long-term commitment. The agri-chains suffer from inadequate infrastructure, coordination, and support for value addition. Indeed, the farmers' strategies are already based on the quest for diversity and self-sufficiency of their farms on the basis of processes largely relying on agroecology. In the face of structural constraints and the level of risk, any major artificialisation of agricultural systems appears to be an unrealistic and undesirable objective for family farms in Vakinankaratra, in contrast to a promotion of agro-ecological intensification that creates jobs and which is already emerging in this region's peasant systems.

Conclusion

In the revived debates and wider discussions on the conceptions of agroecology and the nature of the transitions to promote, the example of the Malagasy Highlands shows how important the starting point of the agricultural models concerned is in planning their evolutions. The trajectory of traditional agriculture – the form of agriculture that is most widespread in Madagascar as also in the whole of sub-Saharan Africa – is that of agroecological intensification. It is also, ultimately, the continuation of this agroecological intensification, very different from the agroecology of practices or integral agroecology which are the usual solutions proposed to replace conventional intensification, that appears to be the most adapted to the resources and the vulnerability of these farms.

For this agroecological intensification to be able to take place, it is imperative to take into account the demographic and economic contexts, the factors of production the farms are equipped with, and the availability of and the accessibility to natural resources. It is necessary to start from existing practices and know-how, which in most cases in sub-Saharan Africa can be considered as agroecological. But this knowledge and these practices are part of activity systems that are both complex and more 'sophisticated' than the 'packages of technological innovations' proposed by the agronomic research community. It is also necessary to assess and understand the actual room for manoeuvre of the systems concerned. One must avoid promoting technically solutions that are desirable and coherent solely in a sectoral perspective or an agricultural specialization perspective, but which may simply not be applicable or accessible. In addition, given the diversity of situations, it is essential to design an approach suitable for territorial diversity. An 'intensification through diversification' thus seems to be the solution. It also imparts value by mobilizing various actors and by building up their capacities of innovation in order to help them manage a greater complexity. It shifts agroecological thinking from the plot or the farm to food systems and territories in which farmers operate.

To support these dynamics, it is therefore necessary to revamp agricultural and food policies to make them territory-centric by identifying and leveraging specific territorial resources. As far as agroecological intensification is concerned, it is a matter of defining agricultural and food strategies that rely on these territorial resources. Of course, this encompasses market strategies, in particular the identification and leveraging of quality brands, but the reasoning can be extended also to the management of food systems adapted to local realities: distribution of value, better linkages between the agrifood industry and local markets, redistribution allowing investment in public goods, ensuring greater consistency with the opportunities and practices of agricultural and non-agricultural diversification, etc.

The example of the Malagasy Highlands finally shows that technical solutions alone will not be sufficient levers to significantly and sustainably improve livelihoods and the quality of agrifood systems. The roadblocks are such that it is difficult to imagine any positive development without massive and coordinated public action, not only at the farm level but also at those of agri-chains and territories.[9] It is essential to generate knowledge to evaluate the different options: agroecology of practices, integral agroecology and agroecological intensification. Above all, we consider it important to determine the strategies that can remove the constraints and to estimate the methods to implement in order to seize the opportunities offered by agroecological intensification, an option that we now believe is the most viable, not only in Vakinankaratra, but also for the majority of family farms in sub-Saharan Africa.

More broadly, and irrespective of the option chosen, it is also necessary to document better the economic and social performance of these different forms of agroecology at the level of activity systems of family farms and at the level of food systems. Indeed, a radical change in the power relations currently prevailing in price-setting mechanisms, and a decision to effectively pay for agricultural and agri-chain services (so called ecosystem services) are needed. Without such changes, agricultural systems and food systems will not be able to initiate an agroecological intensification in today stifled situations in sub-Saharan Africa.

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References

Afsa, 2016. *Agroecology: The Bold Future of Farming in Africa*, Afsa & Toam, Dar es Salaam, Tanzania, 88 p.

Agra, 2016. Africa agriculture status report 2016, Progress towards agricultural transformation in Africa, Alliance for a Green revolution in Africa, https://agra.org/aasr2016/public/assr.pdf (retrieved 27 December 2018).

9. In the case of Madagascar, the poorest households do not have the capacity to diversify their activities or to respond to conventional public policy incentives. Other forms will have be considered to trigger a transformation. Unconditional cash transfers and public facilities can be part of a possible toolbox, but specific innovations remain to be invented.

Altieri M.A., Funes-Monzote F.R., Petersen P., 2012. Agroecologically efficient agricultural systems for smallholder farmers: Contributions to food sovereignty. *Agronomy for Sustainable Development*, 32, 1-13.

Altieri M., Nicholls C., Montalba R., 2017. Technological approaches to sustainable agriculture at a crossroads: An agroecological perspective. *Sustainability*, 9 (3), 349, https://doi.org/10.3390/su9030349.

Baret P., Stassart P., Vanloqueren G., Van Damme J., 2013. Dépasser les verrouillages de régimes socio-techniques des systèmes alimentaires pour construire une transition agro-écologique. *In*: *Actes du Premier Congrès interdisciplinaire du développement durable : Quelle transition pour nos sociétés ? Thème 2, Alimentation, agriculture, élevage* (J.-P. Van Ypersele, M. Hudon, eds), ULB/UCL, 5-14, https://orbi.uliege.be/bitstream/2268/136905/1/Baret%20Stassart%202013%20lock-in.pdf (retrieved 27 December 2018).

Bélières, J.F., Bonnal, P., Bosc, P.M., Losch, B., Marzin, J., Sourisseau, J.M., 2014. *Family farming around the world: Definitions, contributions and public policies*. Collection À Savoir, Paris, AFD. https://www.afd.fr/en/family-farming-around-world-definitions-contributions-and-public-policies (retrieved 30 January 2019).

Bélières J.-F., Burnod P., Rasolofo P., Sourisseau J.-M., 2016. L'illusion de l'abondance : Enjeux fonciers agricoles dans le Vakinankaratra à Madagascar. *In*: *Une nouvelle ruralité émergente. Regards croisés sur les transformations rurales africaines* (D. Pesche, B. Losch, J. Imbernon, eds), NEPAD and CIRAD, 56-57.

Bonny S., 2011. L'agriculture écologiquement intensive : Nature et défis. *Cahiers agricultures*, 20 (6), 451-62, https://doi.org/10.1684/agr.2011.0526.

Bosc P.M., Dabat M.-H., Maître D'hôtel E., 2010. Quelles politiques de développement durable au Mali et à Madagascar ? *Économie rurale*, 320, 24-38.

Bosc P.M., Thirion M.C., Bélières J.F., Bonnal P., Losch B., Marzin J., Sourisseau J.M., eds, 2014. *Les agricultures familiales du monde : Définitions, contributions et politiques publiques*, AFD-CIRAD, Collection À Savoir, Paris, 196 p., https://www.afd.fr/fr/les-agricultures-familiales-du-monde (retrieved 27 December 2018).

Brookfield H.C., 2001. Intensification, and alternative approaches to agricultural change. *Asia Pacific Viewpoint*, 42, 181-192, https://doi.org/10.1111/1467-8373.00143.

Burnod P., Papazian H., Adamczewski A., Bosc P.-M., Tonneau J.-P., Jamin J.-Y., 2011. Régulations des investissements agricoles à grande échelle. Études de Madagascar et du Mali. *Afrique contemporaine*, 2011/1 (237), 111-129, https://doi.org/10.3917/afco.237.0111.

Duru M., Fares M., Therond O., 2014. Un cadre conceptuel pour penser maintenant (et organiser demain) la transition agro-écologique de l'agriculture dans les territoires. *Cahiers agricultures*, 23 (2), 84-95, https://doi.org/10.1684/agr.2014.0691.

FAO, 2015. Final report for the International Symposium on Agroecology for Food Security and Nutrition, 18-19 September 2014, Rome, Italy, http://www.fao.org/3/a-i4327e.pdf (retrieved 27 December 2018).

FAO, 2016. Report of the regional meeting on agroecology in Sub-Saharan Africa, 5-6 November 2015, Dakar, Senegal, http://www.fao.org/3/a-i6364e.pdf (retrieved 27 December 2018).

Giraldo O., 2018. Ecología política de la agricultura. Agroecología y posdesarrollo, El Colegio de la Frontera Sur, San Cristobal de Las Casas, Chiapas, Mexico.

Giraldo O., Rosset P., 2018. Agroecology as a territory in dispute: Between institutionality and social movements. *The Journal of Peasant Studies*, 45 (3), 545-564, https://doi.org/10.1080/03066150.2017.1353496.

Gliessmann S.R., 2015. *Agroecology: The ecology of sustainable food systems*, CRC Press, Boca Raton, United States, 388 p.

Griffon M., 2013. *Qu'est-ce que l'agriculture écologiquement intensive ?* Édition Quæ, Versailles, 224 p.

Griffon M., 2017. Éléments théoriques en agro-écologie : L'intensivité écologique. *OCL*, 24 (3), D302.

Guengant J.P., 2011. Comment bénéficier du dividende démographique ? La démographie au centre des trajectoires de développement, document de recherche, coll. À savoir, no. 9, AFD, IRD, 86 p.

HLPE, 2013. Investing in smallholder agriculture for food security. A report by The High Level Panel of Experts on Food Security and Nutrition, Committee on World Food Security, Rome, 112 p., http://http://www.fao.org/fileadmin/user_upload/hlpe/hlpe_documents/HLPE_Reports/HLPE-Report-6_Investing_in_smallholder_agriculture.pdf (retrieved 27 December 2018).

IAASTD, 2009. Agriculture at a Crossroads, Global Report. International Assessment of Agricultural Knowledge, Science and Technology for Development, Island Press, Washington, DC.

Instat, 2011. Enquête périodique auprès des ménages 2010, EPM-2010, rapport principal, Instat, Antananarivo, Madagascar, 374 p., http://catalog.ihsn.org/index.php/catalog/5127/download/62289 (retrieved 29 January 2019).

IPES-Food, 2016. From uniformity to diversity: A paradigm shift from industrial agriculture to diversified agroecological systems. International Panel of Experts on Sustainable Food Systems, http://www.ipes-food.org/_img/upload/files/UniformityToDiversity_ExecSummary.pdf (retrieved 29 January 2019).

Knox A., Meinzen-Dick R., 1999. Property rights, collective action and technologies for natural resource management, CGIAR SP-CAPRI, policy brief no. 1, Washington, DC.

Le Bras H., 2003. Malthus ou Boserup : Validité et continuité historique des modèles démo-économiques. *Mathématiques et sciences humaines*, 164, hiver 2003, made available online on 18 February 2006, http://journals.openedition.org/msh/2890; https://doi.org/10.4000/msh.2890 (retrieved 27 December 2018).

Losch B., 2016a. Appuyer les dynamiques territoriales pour répondre au défi de l'emploi des jeunes ruraux. *Afrique contemporaine*, 2016/3 (259), 118-121, https://doi.org/10.3917/afco.259.0118.

Losch B., 2016b. Structural transformation to boost youth labour demand in sub-Saharan Africa: The role of agriculture, rural areas and territorial development, Employment working paper no. 204, International Labour Office, Employment Policy Department, Employment and Labour Market Policies Branch, ILO, Geneva, Switzerland.

Losch B., Fréguin-Gresh S., White E., 2012. *Structural Transformation and Rural Change Revisited: Challenges for late developing countries in a globalizing world*, Africa Development Forum, World Bank, Washington, DC, United States, 306 p.

MAEP, 2007. Recensement de l'agriculture, campagne agricole 2004-2005, tome III, Parcelles-superficies, Ministère de l'Agriculture, de l'Élevage et de la Pêche, Antananarivo, Madagascar, October 2007, 346 p., http://www.mpae.gov.mg/wp-content/uploads/pdf/Tome3%20Parcelles-Superficies.pdf (retrieved 29 January 2019).

Naylor R.L., 1996. Energy and resource constraints on intensive agricultural production. *Annual Review of Energy and the Environment*, 21 (1), 99-123.

Penot E., Domas R., Fabre J., Poletti S., Macdowall C., Dugué P., Le Gal P.-Y., 2015. Le technicien propose, le paysan dispose : Le cas de l'adoption des systèmes de culture sous couverture végétale au lac Alaotra, Madagascar. *Cahiers agricultures*, 24 (2), 84-92, https://doi.org/10.1684/agr.2015.0745.

Perret S., Stevens J., 2006. Socio-economic reasons for the low adoption of water conservation technologies by smallholder farmers in southern Africa: A review of the literature. *Development Southern Africa*, 23 (4), 461-476, https://doi.org/10.1080/03768350600927193.

Pesche D., Losch B., Imbernon J., eds, 2016, *Une nouvelle ruralité émergente. Regards croisés sur les transformations rurales africaines. Atlas pour le Programme rural futures du Nepad*, 2e édition revue et augmentée, CIRAD, NEPAD, Montpellier, https://www.cirad.fr/MM/atlas-nepad/Atlas-Nepad-FR.pdf (retrieved 27 December 2018).

Pimentel D., Hepperly P., Hanson J., Douds D., Seidel R., 2005. Environmental, energetic and economic comparisons of organic and conventional farming systems. *BioScience*, 55 (7), 573-582.

Pretty J., Toulmin C., Williams S., 2011. Sustainable intensification in African agriculture. *International Journal of Agricultural Sustainability*, 9 (1), 5-24, http://dx.doi.org/10.3763/ijas.2010.0583.

Raharison T.S., 2014. Politiques publiques de développement à Madagascar et durabilité de l'agriculture et des exploitations agricoles, étude de cas dans le Moyen-Ouest, master Recherche 2, Agriculture, alimentation et développement durable, SupAgro, Montpellier, 130 p.

Raharison T., Bélières J.-F., Salgado P., Autfray P., Razafimahatratra H.M., Rakotofiringa H.Z., 2017. Agro-biodiversité dans les exploitations agricoles familiales du Moyen-Ouest de Vakinankaratra : Des paysans en avance sur la recherche et le développement agricole durable ? Fianarantsoa, 29-30 November 2017, 14.

Rakotoarisoa J., Bélières J.-F., Salgado P., eds, 2016. Agricultural intensification in Madagascar: Public policies and pathways of farms in the Vakinankaratra region, Summary report, CIRAD, FOFIFA, Antananarivo, Madagascar, 135 p., http://agritrop.cirad.fr/582242/1/ProIA_IDCS%20Madagascar_final%20report.pdf (retrieved 27 December 2018).

Razafimahatratra H.M., Raharison T., Bélières J.-F., Autfray P., Salgado P., Rakotofiringa H.Z., 2017. Systèmes de production, pratiques, performances et moyens d'existence des exploitations agricoles du Moyen-Ouest du Vakinankaratra, SPAD CIRAD/FOFIFA/GSDM, Antsirabe (Madagascar), 103 p., http://agritrop.cirad.fr/586881 (retrieved 27 December 2018).

Razafindrakoto M., Roubaud F., Wachsberger J.M., 2017. *L'Énigme et le paradoxe : Économie politique de Madagascar*, IRD Éditions, 280 p.

Reboud X., Hainzelin É., 2017. L'agro-écologie, une discipline aux confins de la science et du politique. *Natures Sciences et Sociétés*, 25, 64-71, https://doi.org/10.1051/nss/2017036.

Scopel E., Triomphe B., Affholder F. Macena Da Silva F.A., Corbeels M., Valadares J.H., Lahmar X.R., Recous S., Bernoux M., Blanchart E., Carvalho Mendes I., De Tourdonnet S., 2013. Conservation agriculture cropping systems in temperate and tropical conditions, performances and impacts: A review. *Agron. Sustain. Dev.*, 33, 113, https://doi.org/10.1007/s13593-012-0106-9.

Serpantié G., 2013. Genèse malgache d'un modèle agro-écologique : Le système de riziculture intensive (SRI). *Cahiers agricultures*, 22 (5), 393-400, https://doi.org/10.1684/agr.2013.0659.

Sourisseau J.-M., Bélières J.-F., Bourgeois R., Soumaré M., Rasolofo P., Guengant J.-P., Bougnoux N., 2016. *Penser ensemble l'avenir d'un territoire : Diagnostic et prospective territoriale au Mali et à Madagascar*, AFD, France, 176 p., https://www.afd.fr/fr/penser-ensemble-avenir-territoire (retrieved 27 December 2018).

Thérond O., Duru M., Roger-Estrade J., Richard G., 2017. A new analytical framework of farming system and agriculture model diversities: A review. *Agronomy for Sustainable Development*, 37 (21), http://dx.doi.org/10.1007/s13593-017-0429-7.

Tittonell P., Scopel E., Andrieu N., Posthumus H., Mapfumo P., Corbeels M., Van Halsema G.E., Lahmar R., Lugandu S., Rakotoarisoa J., Mtambanengwe F., Pound B., Chikowo R., Naudin K., Triomph B., Mkomwa S., 2012. Agroecology based aggradation-conservation agriculture (Abaco): Targeting innovations to combat soil degradation and food insecurity in semi-arid Africa. *Field Crop Res.*, 132, 168-174.

United Nations, 2017. World Population Prospects: The 2017 revision, key findings and advance, United Nations, Department of Economic and Social Affairs, Population Division, working paper, no. ESA/P/WP/248, 53 p.

Wezel A., Bellon S., Doré T., Francis C., Vallod D., David C., 2009. Agroecology as a science, a movement and a practice. A review. *Agronomy for Sustainable Development*, 29 (4), 503-515, https://doi.org/10.1051/agro/2009004.

Whiteside M., 1998. *Living Farms: Encouraging sustainable smallholders in Southern Africa*, Earthscan publ., London, United Kingdom, 217 p.